PUAIOHI FIVE-YEAR RECOVERY WORK PLAN 2016 - 2020

(Updated August 2017)

PURPOSE. The long-term recovery goals, delisting criteria, recovery strategy, and a comprehensive list of recovery tasks for the Puaiohi are provided in the Final Revised Recovery Plan for Hawaiian Forest Birds (USFWS 2006). The purpose of this work plan is to identify interim recovery objectives for the Puaiohi that can be realized within five years, and to describe succinctly the actions needed to reach those interim objectives. Identification of interim recovery objectives will help ensure that initial conservation efforts by different agencies or groups are directed toward the same ultimate goals, encourage efficient use of limited recovery resources, and provide milestones that can be used to track and evaluate progress toward recovery. Realization of these milestones will provide evidence that progress is being made toward eventual recovery. Failure in realizing these milestones may indicate that additional effort and funding are needed or the current recovery strategy is not effective.

SPECIES SUMMARY. The Puaiohi, or Small Kauaʻi Thrush *(Myadestes palmeri),* is a medium-sized (37 – 43 g), slender, long-legged thrush endemic to Kauaʻi. Adults are olive-brown above, gray below, with a diagnostic white-eye-ring and outer rectrices. Legs are light pink and the bill is black (Snetsinger *et al.* 1999). Males and females are similar. Juveniles have distinctive spots and scalloping on their breast and wings; some SY birds may retain a degree of scalloping. The song is simple and consists of a preparatory whistle and a prolonged trill, followed by several sharp descending notes; call note is a simple, dry, raspy hiss (Snetsinger *et al.* 1999). Puaiohi are most often observed alone or in pairs, as opposed to social groups or multi-species flocks.

The species occurs in wet (>6,000 mm rain / year) montane forest in stream valleys and associated ridges above 1,050 m elevation in the southern and central Alaka'i Plateau (Scott *et al.* 1986, Snetsinger *et al.* 1999, Crampton *et al.* 2017). Puaiohi are found in wet native montane forests dominated by ʻōhiʻa (*Metrosideros polymorpha*), ʻōlapa (*Cheirodendron trigynum*), lapalapa (*C. platyphyllum*), ʻōhia hʻa (*Syzygium sandwicensis*), kāwaʻu (*Ilex anomala*), and kōlea (*Myrsine lessertiana*), with a diverse understory of native plants including ʻōhelo (*Vaccinium calycinum*), and kanawao (*Broussaisia arguta*). Puaiohi feed on insects and fruits of native plants, particularly ʻōlapa, lapalapa, ʻōhia hʻa, kanawao, ʻōhelo, paʻiniu *(Astelia* spp.), pūkiawe *(Styphelia tameiameiae),* kāwaʻu, thimbleberry (*Rubus rosifolius*), *Clermontia fauriei* and pilo *(Coprosma* spp.) (Snetsinger*et al*. 1999; Kaushik *et al.*, *in review*). They do not appear to consume fruits of non-native plants (Kaushik *et al. 1999).* The non-fruit portion of their diet consists of a wide variety of invertebrates (Berger 1981, Snetsinger *et al.* 1999). Puaiohi forge primarily in lower canopy, often on terminal fruit or leaf clusters; rarely on the ground. Arthropods are gleaned from terminal leaf clusters, extracted from moss or bark, and removed from ripe fruits (Perkins 1903, Snetsinger *et al*. 1999).

Puaiohi nest in cavities or ledges on cliff faces that are concealed by mosses and ferns, or rarely in trees (Snetsinger *et al.* 2005, Kauai Forest Bird Recovery Project (KFBRP), unpubl. data). Nesting occurs from March to mid-September, with a peak from April to June (Snetsinger *et al.* 2005). Females build nests, and incubate and brood young. Clutch size is almost always two, and eggs hatch after 13 to 15 days of incubation. Both males and females provision nestlings, but males usually feed fledglings while females frequently initiate another nesting attempt. Second-year and hatch-year birds occasionally assist in nest defense and feeding nestlings and fledglings (Snetsinger *et al*. 1999). Nest survival appears to be high, with nest predation (primarily by rats) being the most common cause of nest failure (KFBRP, unpubl. data). Young often remain near the ground for two to four days after fledging, where they may be vulnerable to predation.

Annual productivity is variable, ranging from 0.4 to 4.9 fledglings / pair / year, and positively correlatd with total rainfall in the previous wet season (Snetsinger et al. 2005, Fantle-Lepcyk *et al.* 2016). Juvenile dispersal distance in the Mōhihi Stream was 279 ± 157 m (mean ± SD, *n* = 5) and 598 ± 300 m in the Halepāʻākai Stream (*n* = 8 banded birds, KFBRP, unpubl. data.). Three radio-tagged hatch year Puaiohi in fall 2014 moved 610.5-796m before dying (Puaiohi that moved the shortest distance) or removing their radiotags (the other two; Bonnette *et al.* 2016). Adult survival was estimated at 74% and juvenile survival at 25% in the Mōhihi (Snetsinger *et al.* 2005). Range-wide, wild adult males had higher survival (0.71 ± 0.09) than wild adult females (0.46 ± 0.12; VanderWerf *et al*., 2014). Wild juveniles had even lower survival (0.23 ± 0.06). Two wild birds lived to be at least six years of age. Birds with chronic malaria infection at the time of capture had survival similar to that of birds that were not infected at the time of capture (VanderWerf *et al*. 2014).

POPULATION STATUS. First collected in 1891 by Henry Palmer, the Puaiohi was the last bird endemic to Kauaʻi to be discovered. Bryan and Seale (1901) failed to detect the species during a three week collecting trip in 1900. Perkins (1903) considered the species rare and in 1895, the Kāmaʻo (*M. myadestinus*) outnumbered the Puaiohi 100 to 1 in mesic forests of Halemanu Valley (Perkins 1903). Puaiohi went unreported for 45 years until two birds were observed in 1940 in the southern Alakaʻi (Donaghho 1941). In 1960, Richardson and Bowles (1964) found at least 17 individuals. The first quantitative data on the population and distribution was based on 866 half-hour counts conducted from 1968-1973. These surveys estimated an island-wide population of 177 ± 96 birds and identified isolated populations on Lāʻau Ridge and above Nuʻalolo west of Kōkeʻe (USFWS 1983, Snetsinger *et al.* 1999). Most individuals were found in Alakaʻi Plateau north of Koaiʻe Valley at elevations ranging from 1,100-1,250 m, and smaller numbers were found between 900 and 1,100 m elevation on Kohua Ridge and between 1,370 and 1,450 m elevation near the USGS cabin at Waiʻaleʻale. In 1981, the number of Puaiohi estimated to occur in a 25 km^2 area of the southeastern Alakaʻi Wilderness Preserve was 20 ± 17 (Scott *et al.* 1986). Comparing these surveys to those conducted by the USFWS is problematic because of a lack of overlap in sampling locations and differing survey methods. Rare bird surveys conducted on Kauaʻi in the spring of 1996 yielded 55 to 70 individuals and found birds widely distributed across the plateau between 1,060 and 1,280 m elevation. These surveys and demographic research suggested a population exceeding 200 birds (Reynolds and Snetsinger 2001).

The current population of the Puaiohi is estimated at about 494 (95% CI 414–580) birds and appears to be stable (Crampton *et al.*, 2017). The breeding population is restricted to an area of < 20 km^2 and 75% occurs in 10 km^2 (Fig. 1). Puaiohi occur in high densities (up to 11 pairs / km of stream) in three adjacent drainages: the Upper Mōhihi, Upper Waiakoali, and the northeastern upper Kawaikōī, but density declines with elevation (Snetsinger *et al.* 1999, Crampton *et al.*, 2017). The upper reaches of the Halehaha and Halepāʻākai drainages support a medium-density population of about 5 pairs / km of stream and low-density populations occur in the lower Waiaʻalae / unnamed drainage (1.25 pairs / km; Pratt *et al.* 2002; Crampton *et al.* 2017) and lower Kawaikōī / Kauaikinana (0.5 pair / km). In 1994, two small, low-density populations were detected on private lands along the Halekua and Waiau streams at the southern edge of the species' range, but neither population was detected during surveys in March 2000 (Telfer pers. comm.). Surveys in March 2000 and Spring 2012 confirmed the existence of a small population along an upper tributary of the Koaiʻe Stream, although its size and extent are unknown (Foster, unpubl. data; Crampton *et al.* 2017). The best predictor of Puaiohi occupancy is the number and size of the cliffs along a stream (Crampton *et al.*, 2017).

MANAGEMENT / PROTECTION TO DATE. The Puaiohi was federally listed as endangered in March of 1967 (USFWS 2006). Studies to determine distribution, life history and demography of the Puaiohi were conducted between 1996 and 2002 by USGS and have been ongoing since 2003 by the

Kaua‘i Forest Bird Recovery Project (KFBRP). Weed control is being conducted by The Nature Conservancy and Kōke‘e Resource Conservation Program, not for profit groups on Kaua’i. The Kaua‘i Watershed Alliance, a consortium of landowners on Kaua’i, constructed a fence in 2011 to protect the southeastern Alaka‘i Wilderness Preserve from ungulates, and has removed all but a handful of pigs. The Hono O Nā Pali Natural Area Reserve (NAR) fence was completed in 2014, and ungulate and predator control is ongoing in this NAR. Fencing of the approximately 500 ha Halehaha Unit, which includes Halepa’akai, was completed in 2016, and ungulate and rat control is ongoing in this unit. Fences around the Drinking Glass and Koaie Units are planned for the next five years. Extensive pre and post fence construction forest bird surveys and vegetation data collection to assess the immediate impact of the southeastern Alaka‘i fence on birds and plants; no differences were detected. By the end of the 2016 breeding season more than 300 self-resetting A24 Goodnature rat traps were deployed across Puaiohi primary habitat at Halepa’akai, in attempt to minimize the amount of rodent nest predation, with preliminary results suggesting rat numbers have declined (L. Crampton *et al. in litt*. 2015, Else 2016). An experimental larval mosquito control program was initiated in Kawaikoi Stream of the NAR in 2016 (L. Crampton, pers. comm).

A captive propagation and release program was implemented for the Puaiohi by the Hawaii Endangered Bird Conservation Program (HEBCP), which is a collaboration of the USFWS, DOFAW, and San Diego Zoo Global focused on conservation breeding. Between 1999 and 2017, 240 birds were released at three sites (Kuehler *et al*. 2000, Woodworth *et al.* 2009, Lieberman and Kuehler 2009, San Diego Zoo Global, unpubl. data). Despite this effort, no known new subpopulations have been permanently established even though a few released Puaiohi have fledged young with both wild and captive-bred mates (Switzer *et al*., 2013). This may indicate that suitable habitat is saturated. Recruitment of captive birds into the breeding population appears to be related to the local density of the wild birds. In the low density Kawaikōī drainage 13.8% of captive birds have bred, while in the higher density Halepā‘ākai drainage only 1.4% have bred (KFBRP, unpubl. data). However, even in the Kawaikōī, birds only breed in one year if at all, and are not seen in subsequent years. Furthermore, retention of captive bred birds seems to have decreased over time (Switzer *et al*., 2013). Based on mark-resight data between 2005-2011, captive-bred birds released when <1 yr old had similar survival (0.26 $\pm$ 0.21) to that of wild juveniles, but captive-bred birds released as adults old had very low survival (0.05 $\pm$ 0.06). Only 8 of 123 (7%) captive-bred birds released between 2005 and 2011 were resighted in the wild beyond the 40-day period of telemetry monitoring (VanderWerf *et al*., 2014). These data, those suggesting that the wild Puaiohi population was stable, and shifting priorities in conservation breeding, led the Hawaii Endangered Bird Conservation Program to decide to terminate the Puaiohi breeding program in 2015, which would also help make room for other species. Most of the remaining captive individuals (15 birds in 2016 and three in 2017) were then released at Halepa’akai (KFBRP, unpubl. data). One bird, unfit for release, remains in captivity.

KFBRP and partners have experimented off and on since 2000 with rat proof nest boxes to increase the availability of nest sites (partly under the assumption, perhaps unwarranted, that nest sites are limited), provide predator-proof nesting options, and expand range. Puaiohi have occasionally nested in nest boxes of different styles, most recently in 2012. Efforts in 2011 and 2012 succeeded in making nest boxes rat proof, and in 2013, KFBRP developed a means of remotely surveying nest box use with PIR sensors and microcontrollers. Data from temperature and humidity sensitive iButtons in both nest boxes and nest cavities suggest that the primary barrier to widespread adoption of next boxes may be their more variable temperature and humidity (KFBRP, unpubl. data). Attempts to insulate nest boxes have been attempted but are currently on hold due to a lack of resources and the recent focus on ‘Akikiki and ‘Akeke’e conservation measures.

PRIMARY THREATS. Non-native disease appears to limit the distribution of many native Hawaiian forest birds, including the Puaiohi (van Riper *et al.* 1986, Atkinson *et al.* 1995, Atkinson and LaPointe 2009), and global climate change may exacerbate this threat by allowing an increase in the elevation at which regular transmission of avian malaria and avian pox virus occurs (Reiter 1998, Benning *et al.* 2002, Harvell *et al.* 2002, Hay *et al.* 2002, Atkinson *et al.*, 2014). Currently, there are no forested areas on Kauaʻi where the mean ambient temperature prevents the seasonal incursion of malaria; mosquitoes and malaria can survive across all parts of the island, at least periodically (Benning *et al.* 2002). Benning *et al.* (2002) used GIS simulation to show that an increase in temperature of 2° C, which is a conservative figure based on recent data (IPCC 2007), would result in an 85 % decrease in the land area on Kauaʻi where malaria transmission currently is only periodic. Without translocation to higher islands, removal of the vector, or the development of disease resistance, the loss of such a large proportion of suitable habitat would likely result in extinction of the Puaiohi (although see below) (Pounds *et al.* 1999, Still *et al.* 1999). At least three captive birds that died soon after release were determined to be infected with malaria. Thus, disease may limit Puaiohi from inhabiting low elevation areas with suitable nesting habitat. However, Atkinson *et al. (*2014) documented a 22% increase in malaria prevalence in this species between 1997-1999 and 2011-2013, which indicates some tolerance; and VanderWerf *et al*. (2014) showed that Puaiohi with chronic malaria survived as well as uninfected birds, so malaria may not influence Puaiohi population size and range as much as it does for other species.

The habitat of the Puaiohi has been, and continues to be, negatively affected by invasive alien plants that displace native plants used for foraging, and by feral ungulates, particularly feral pigs (*Sus scrofa*) and goats (*Capra hircus*) (Foster *et al.* 2004, Woodworth *et al.* 2009). Puaiohi depend on areas of intact native forest for foraging and nesting. Feral ungulates negatively affect native forest by browsing, causing soil erosion, disrupting regeneration, spreading invasive plant seeds, facilitating the invasion of alien plants, and creating breeding habitat for mosquitoes (Cabin *et al.* 2000, Scott *et al.* 2001, USFWS 2006). Degradation of forest habitat has likely played an important role in the range contraction of the Puaiohi, and may be one of the reasons they are not found at low elevation (Crampton *et al.*, submitted). Because the Puaiohi is frugivorous, loss of native food plants is particularly detrimental and invasive plants have drastically changed the structure of native forests. Kalihi ginger (*Hedychium gardnerianum*), strawberry guava (*Psidium cattleianum*), and Australian tree fern (*Cyathea cooperi*) suppress native food plants. Daisy fleabane (*Erigeron karvinskianus*) will cover nesting walls, reducing their suitability for nest sites (Woodworth *et al.* 2009).

Introduced predators are one of the most serious threats to Hawaiian forest birds, particularly during nesting (Atkinson 1977; Scott *et al.* 1986; VanderWerf and Smith 2002). Predation by rats *(Rattus* spp.) is likely a serious threat to Puaiohi, and is the most likely cause of the observed low juvenile and female survival (VanderWerf *et al.*, 2014). Although their habit of nesting on steep cliff faces may provide some protection, nest predation can be as high as 38% (Tweed *et al.* 2006). Snetsinger *et al.* (2005) demonstrated that nests of wild pairs protected by rat bait stations fledged significantly more birds than untreated nests in some years. In contrast, Tweed *et al.* (2006) reported that ground based rodent control proved ineffective at protecting nests where at least one adult was a captive-released bird. The difference between these two studies could be related to annual variation in rat abundance, or the behavior of wild and captive release birds. The tendency of young Puaiohi to remain close to the ground for several days after fledging probably makes them vulnerable to predation. Furthermore, rodents such as rats and mice have indirect impacts on forest birds by consuming insects and seeds and fruits of native plants. Two species of owls, the native Pueo (*Asio flammeus sandwichensis*) and the introduced Barn Owl (*Tyto alba*) also occur on Kauaʻi and are known to prey on forest birds (Snetsinger *et al.* 1994). Feral cats (*Felis catus*) also are present on the Alakaʻi Plateau.

Major hurricanes struck Kauaʻi in 1959, 1982, and 1992 and significantly affected native habitats by destroying native habitat, creating gaps into which alien plants could expand, and spreading invasive plants. Because Puaiohi occupy stream drainages, which presumably offer some protection, it is difficult to assess the population level affects of hurricanes. However, the populations identified on Lāʻau Ridge and above Nuʻalolo west of Kōkeʻe (USFWS 1983) did not persist after these hurricanes.

A number of other factors are possibly contributing to the decline of this species. The effects of non-native arthropod predators and competitors on the insect prey consumed by Puaiohi during the breeding season are completely unknown. Threats or stressors may interact with each other and increase their negative impact on Puaiohi. For example, birds experiencing malarial symptoms may be more susceptible to predation. Finally, single island endemics like the Puaiohi are inherently more vulnerable to extinction than widespread species because of the higher risks posed to a single population by random demographic fluctuations and localized catastrophes such as hurricanes, fires, and disease outbreaks (Wiley and Wunderle 1994), and potentially genetic issues (Keller and Waller 2002, although see Brodie 2007). As populations and ranges of island birds decline due to other threats, the extinction risk from catastrophic events also increases.

RECOVERY STRATEGY. Several tools can potentially be used to manage Puaiohi, including captive propagation as an insurance population, which also may include the breeding of disease resistant individuals. However, release of captive bred birds into current habitat on Kauai should not be re-attempted until threats are controlled in the wild. More effective measures to recover Puaiohi at this time may include controlling alien plants; mosquito control; fencing and ungulate removal from fenced areas, and potentially translocating the species to other islands. Controlling predators or deploying rat-resistant artificial nest boxes may facilitate the evolution of disease resistance (Kilpatrick 2006). The most appropriate strategy depends on the size, distribution, and trend of the population. The best evidence indicates that the population is approximately 500 individuals, little suitable unoccupied habitat exists, and there is no evidence of a declining trend (Crampton *et al.*, 2017). Thus for the next five-years, management should be directed at wild birds, and not captive propagation. At this time, only one Puaiohi remains in captivity.

Progress made on Interim Recovery Objectives and Actions [2010 - 2015]

The recovery strategy from 2010-2015 emphasized developing a Puaiohi specific survey method and resurveying the population. Much progress was made on this objective. A protocol based on occupancy survey methodology was developed by KFBRP and USGS in 2011 and implemented on 12 randomly selected streams across the range in 2011-2013 (Crampton et al. 2017). The surveys included areas of possibly suitable habitat not previously surveyed, as well as streams in the core Puaiohi range. These surveys included Hono O Na Pali NAR, where a few Puaiohi were found, but did not include Namolokama, or Lāʻau Ridge No captive bred released birds were resighted during these surveys or other field, and due to shortage of staff, we were not able to establish a more comprehensive effort. Nonetheless, since we surveyed some of the best known habitat, it seems possible that we should have detected at least one captive-bred individual should it have persisted. During occupancy surveys, we measured various habitat variables, emphasizing topographic features such as cliff height, slope, bank width, stream sinuosity etc, as well as elevation and % cover. Cliff height and number of cliffs were the best predictors of Puaiohi occupancy. We also developed a model based on these surveys to predict probability of occupancy of unsurveyed streams and combined these probabilities with demographic data to estimate population size. We attempted to structure the previous survey data so that it could be analyzed in the occupancy framework, but the level of temporal and spatial resolution of these data precluded their inclusion. Nonetheless, the predictions of occupancy made by T. Savre (unpubl. Data) largely matched our model predictions. Groundtruthing these areas to validate this model is a major current focus of the project. LiDAR acquired in 2017 will be useful in modeling topographic variables such as cliffs across the range and improving our models. We should consider vegetation variables, such as fruit abundance.

A second goal of the 2010-2015 Plan was to determine limiting life stages and investigate threats. VanderWerf et al. (2014) established that juvenile survival was lower than survival of wild adults, indicating that recruitment may limit population growth, as may high female mortality, using data collected at Halepāʻākai and other sites from 2007-2010. The most parsimonious reason for the difference between male and female survivalis rat predation a nests. Jean Fantle-Lepcyk completed a PVA showing that juvenile and female survival have the most influence on population growth and rodent control is the management option most likely to increase population size.

Since 2011, we have not rigorously monitored nests at Halepāʻākai, but did monitor nests at Mohihi from 2011-2015. We have continued to resight banded birds at all sites. We attached radio transmitters to fledglings in the late summer and fall (n = 6) at HPK. Birds moved several hundred meters (Bonnette et al. 2017). One was found dead. We have deployed nest cameras at both Mohihi and Halepa'akai on a limited basis; none have yet recorded nest predation of Puaiohi. Several lines of evidence indicate that Puaiohi are relatively tolerant to disease. Malaria prevalence in Puaiohi increased by 22% between 1997-1999 and 2011-2013 (Atkinson et al. 2014), and survival of infected Puaiohi was similar to that of uninfected birds (Vanderwerf et al. 2014).

A third goal was to manage to explore ways of managing the threat of disease. We have not explored breeding disease resistant individuals. KFBRP and USGS are currently (fall 2016-7) conducting a trial study to determine the effectiveness of *Bacillus thuringensis israelenis* in reducing adult mosquito populations. Other emerging technologies are being reviewed by Federal and State agencies, and some funding may be pursued to help develop the most promising ones. It has been hypothesized that improving survival by controlling rodents may facilitate the evolution of disease resistance. In 2014 KFBRP initiated an online fundraising campaign to raise money to purchase GoodNature rat traps and awareness about rodents as a threat to native Hawaiian birds. Subsequently, NFWF and ABC donated more traps, and currently approximately 300 traps are deployed along streams at Halepa'akai. Also, in 2011 and 2012 KFBRP succeeded in making nest boxes rat proof, and in 2013, they developed a means of remotely surveying nest box use with PIR sensors and microcontrollers. As of 2014 there was no evidence these boxes had been used, possibly because they have more variable temperature and humidity than nest cavities. Since 2014 we have not had resources to continue this project, which would require modifications to stabilize nest box microclimate.

On the captive breeding and translocation fronts, we were to *i*nvestigate allowing second broods of captive-raised birds to fledge from nest boxes, which was done on a limited basis in the 2016 and 2017 releases, as we phased out the captive breeding program. We did not experiment with playback to promote retention of released birds. *No progress was made on i*nvestigating the feasibility of translocating birds to higher Hawaiian Islands (e.g., Maui).

KFBRP has been very active in the outreach area. We developed a website in 2011. The KFBRP Facebook page has reached over 4000 likes, we have started an Instagram account, and send out newsletters on a regular basis. The work of KFBRP and partners has been covered several times in local and national newspapers and on a variety of online news sites. KFBRP sets up booths at 4-6 festivals and outreach events each year, and has started doing classroom presentations. KFBRP published a children's book in 2015 and has been donating it to elementary classrooms on Kaua'i.

Interim Recovery Objectives and Actions (2016-2020)

In order to meet the long-range recovery goals for Puaiohi, and in light of the above progress made on recovery to date, the following short-term goals and actions should be prioritized for 2016-2020, in rough order of priority.

- Continue to monitor population size, distribution and demographic indices, and assess habitat use
  - Groundtruth occupancy model predictions of distribution and population size with a combination of on-the-ground and remote acoustic monitoring
  - At a minimum, a select number of streams should be monitored every few years with a combination of on-the-ground and remote acoustic monitoring
  - From LiDAR, extract refined topographic and vegetation metrics that might better predict Puaiohi distribution and allow monitoring of temporal changes
  - Record select vegetation indicators (e.g., % cover by weeds; presence of key fruiting species) at song meter and occupancy survey stations
  - Continue to investigate fine-scale habitat associations (nest, territory) and seasonal changes in habitat (potentially with telemetry)
  - Investigate potential of eDNA to document Puaiohi occupancy
  - Continue to monitor adult and juvenile survival, especially as a function of different levels of threat (or threat abatement).
- Continue to assess and mitigate impacts of invasive weeds and disease on Puaiohi occupancy, survival and fecundity
  - Mistnet Puaiohi and take blood and faecal samples
  - Measure reproductive success and survival in areas of high and low disease prevalence and pristine and weed-invaded areas; as a surrogate could compare ungulate-free areas to unfenced areas
  - Continue to control weeds and ungulates, and restore native forests
  - Put feeders at known territories and assess visitation rates and fledging success
- Continue to implement and evaluate effectiveness of predator control on the Puaiohi population.
  - Expand the amount of area under rodent control
  - Monitor nests on trapping grids and control areas with in person checks and remote cameras
  - Monitor juvenile and female survival in areas being trapped and control areas.
  - Investigate nest site selection in areas of low and high rat density
- Develop and implement landscape level mosquito vector control
  - Sample for mosquitoes with larval and adult surveys
  - Continue to experiment with methods to control mosquitoes
- Investigate feasibility of translocating Puaiohi to higher Hawaiian Islands (e.g., Maui).
  - Seek funding to develop a translocation plan
- Continue to investigate nest box modifications to increase adoption by Puaiohi
  - Continue to investigate ways to stabilize microclimate and making them look “natural”

- Experiment with food supplementation and social attraction to draw birds to nest boxes
- Consider nest site modification as an alternative (include rat proofing)

If these objectives are met within five years, then new interim recovery objectives should be identified that will continue to guide progress toward full recovery. If these objectives are not met within five years, then the causes for failure should be examined and rectified if possible or reason for continued pursuit of recovery objective explained. If it is not possible to correct the causes for failure and the current strategy is not considered effective, then a new strategy should be developed.

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